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Species of *Macromitrium* (Orthotrichaceae) New to the Mindanao Region and the Philippines with One Species New to Science

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Numerous collections of *Macromitrium* were made during a joint expedition between the California Academy of Sciences and the Central Mindanao State University in 2014 and 2015 from the region of Mindanao in the Philippines. Two *Macromitrium* species collected from the Mindanao Region are new records for the Philippine flora, along with a species, *M. eddyi*. Range extensions of four species of *Macromitrium* across the island of Mindanao are mentioned. A review of the species diversity of *Macromitrium* between the Luzon Island region and the Mindanao region is also provided.

KEYWORDS: Asian mosses, bryophyte inventory, Malesia, Mindanao Island, new records, Papua New Guinea, Philippines, species distribution

Mindanao Island (ca 104,630 km^2) and its off shore, small islands, although slightly smaller than and ranking second in total land area next to Luzon Island (ca 109,965 km^2), have only half the number of moss species documented for the latter (Linis and Tan 2008). However, recent reports of collecting activities of mosses of Mindanao Island have added 60 new species records to the island (Tan and Shevock, 2014; Azuelo et al. 2015; Tan et al. 2015). Here we focus our study on the epiphytic moss genus, *Macromitrium* Brid., which has a different assemblage of species occurring on these two major Philippine island groups.

Early in this century, 21 species of *Macromitrium* were documented from the Philippines with 18 species reported from Luzon and 13 species from Mindanao (see Tan and Iwatsuki 1991; Tan et al. 2000). The two new expeditions organized by the California Academy of Sciences and the CEBREM Office of Central Mindanao State University in 2014 and 2015 have added three new records of *Macromitrium* (Tan et al. 2015; this publication), and one reported below as a species new to science.

An updated list of the 19 species and one variety of *Macromitrium* in Mindanao is appended below based on Tan et al. (2000), Linis (2010), Tan et al. (2015) and this publication. Of these, *M. archboldii* E.B. Bartram, *M. eddyi* B.C. Tan & Shevock sp. nov., *M. mindorense* Broth., *M. ochraceum* (Dozy & Molk.) Müll. Hal. and *M. tylostomum* Mitt. ex Bosch & Sande Lac. are not documented from Luzon Island. On the other hand, *M. benguetense* Williams, *M. fasciculare* Mitt., *M. formosae* Card., *M. nepalense* (Hook. & Grev.) Schwägr., and *M. robinsonii* Williams still have no specimens found in Mindanao. It is noteworthy that Luzon has received considerably more bryophyte inventory work since it is within the Manila area compared to distant Mindanao. We speculate that additional Wallacea-Australian *Macromitrium* are unlikely to occur in the northern

half of the Philippine archipelago based on this collection history. However, we expect additional *Macromitrium* species documented from either adjacent Indonesia or Papua New Guinea could be discovered in Mindanao with additional field inventory.

New Species

Dr. Alan Eddy (1937–1998), while affiliated with the herbarium of the British Museum (BM), was working on a multi-volumed *Handbook of Malesian Mosses* up to the time of his death. The third and final fascicle he published includes the moss family Orthotrichaceae (Eddy 1996). *Macromitrium* is a very large and complex genus with over 350 species (Crosby et al. 2000). During the development of the *Macromitrium* treatment he encountered a single specimen that could not be assigned to any of the known Malesian species. He decided to include this specimen and reference it simply as '*Macromitrium* sp.' with the hope that other bryologists would eventually encounter it. Therefore, he was the first person to recognize this *Macromitrium* as likely to be new to science. Although he decided not to name it as a new species based on a single sample, he nonetheless provided a detailed description (p. 38) and prepared an illustration (fig. 350) of this taxon based on the specimen labeled as "*Stevens no. 55716*" (see Eddy 1996). While examining our recently collected *Macromitrium* collections from Mindanao, we used the *Macromitrium* key in Eddy (1996) and realized that one of our unknown specimens matched the illustration and description entry as '*Macromitrium* sp.' We borrowed this collection from BM and compared it to the Philippine specimen (*Shevock 44672*) from Mt. Kitanglad Range Natural Park. We determined the species to be one and the same.

***Macromitirum eddyi* B. C. Tan & Shevock, sp. nov.**

Figures 1–3.

Holotype: **Papua New Guinea**: Milne Bay District, Raba-Raba Sub-district, bottom of scarp of Tantam Plateau, Mt. Suckling, 1645 m., in shaded forest, common on wood, 20 Jul 1972, coll. *P.F. Stevens* [*LAE 55716*] (BM!; isotypes, CANB, E, L, LAE). Paratype: **Philippines**: **Mindanao Island**: Bukidnon Province, on access dirt road to trail less than 0.5 km above Lantapan Village toward Mt. Dulang-Dulang in Kitanglad Range Natural Park, on trunk of *Gmelina* in disturbed forest near cultivated field, 20 Apr 2014, *Shevock 44672* (CAS; isoparatype, CMUH, NY, UC).

The new species can be identified easily using the key to the species of *Macromitrium* published in Eddy (1996). Morphologically the new species is identified by its slender and long branches with leaves arranged in five straight, longitudinal rows, when wet. Other diagnostic characters include leaves with acute to acuminate apices, percurrent to shortly excurrent costae, papillose upper leaf cells, and tuberculate lower leaf cells. In addition, the basal leaf cells are thick-walled with straight to curved lumina.

Below we reproduce verbatim the species description prepared by Eddy (1996) in whose honor we name this new species in recognition of his great contribution to our knowledge of Malesian mosses. Additionally, we include herewith photographs of the specimen of the Philippine paratype to complement the nice illustration of what is now *M. eddyi* that appears in Eddy (1996).

"Plants yellowish, slender, with elongate, sparingly ramifying branches up to 5 cm long. Leaves closely set, squarrose-recurved and markedly pentastichous when moist, erect and appressed with crisped upper limbs when dry, rendering the branches string-like in appearance; triangular lanceolate, canaliculate, finely acuminate, up to 3 mm long; apex finely acute, pellucid. Costa percurrent to short excurrent. Upper lamina cells small, isodiametric, ca 6–9 μm diameter, densely pluripapillose and obscure; lower lamina cells elongate with strongly thickened walls and

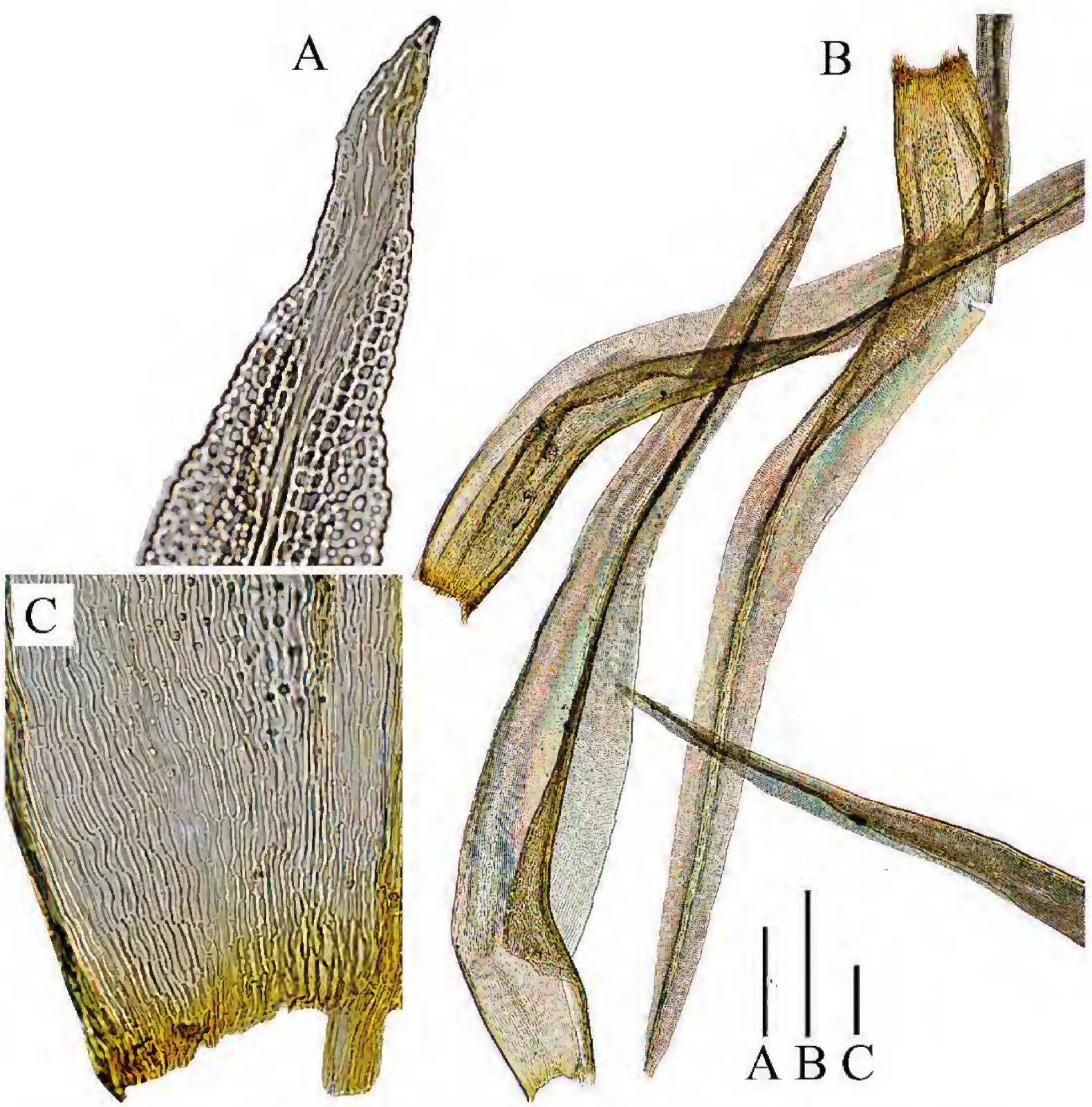

FIGURE 1. *Macromitrium eddyi* B.C. Tan & Shevock from the holotype, *Stevens 55716* (BM). A. Leaf apex with percurrent costa of elongate cells and upper laminal cells multipapillose. B. Leaves. C. Lower laminal cells elongate with thickened walls and narrow, straight to somewhat curved lumina cells conspicuously tuberculate. Scale bars: A, C: 5 μm, B. 0.5 mm.

FIGURE 2. Habit of *Macromitrium eddyi* stems in a dry state. *Shevock 44672* (CAS).

FIGURE 3. Growth habit of *Macromitrium eddyi* from *Shevock 44672* (CAS).

narrow, straight lumina, conspicuously tuberculate. Perichaetial leaves narrowly triangular-lanceolate, plicate, very finely acuminate and filiform-pointed. Seta short, about 3 mm long, smooth; capsule ovoid, smooth, small, the urn about 1 mm long and 0.8 mm wide; peristome of pale, rather fugacious, triangular exostome teeth; calyptra naked."

New Species Records for the Philippines

Macromitrium tylostomum Mitt. ex Bosch & Sande Lac.

Specimen examined:— **Mindanao Island**: North Cotabato Province: Mt. Apo, trail to Plot H of EDC, ca 1900 m, 29 Apr 2014, *Tan 2014-132* (CAS, UC).

Among members of *Macromitrium* in the Philippines, this is one of three species that have the laminal cells rounded to quadrate in shape from apex to near base. It differs from the other two species, *M. orthostichum* Nees ex Schwägr. and *M. falcatulum* Müll. Hal. in having smooth and not papillose basal laminal cells. Although the upper and middle laminal cells are smooth, thin-walled and budging, the basal laminal cells of *M. tylostomum* are thick-walled and decorated with tall papillae. The cylindrical capsule attached to a short, smooth seta is also distinctive. Outside of the Philippines, *M. tylostomum* is known from Java, Sumatra and Papua New Guinea.

Macromitrium yuleanum Broth. & Geheeb

Specimens examined:— **Mindanao Island**: Bukidnon Province: Mt. Kitanglad Range Natural Park, midslope of Mt. Dulan-Dulang Peak along the ridge trail separating headwaters of Alanib River and Magnao River, on fallen branch in mixed hardwood forest, 21–23 Apr 2014, *Shevock 44727, 44779, 44842* (CAS, CMUH, NY, UC).

According to Vitt et al. (1995), this is the most common, large sized and variable species of *Macromitrium* at high elevation in Huon Peninsula of Papua New Guinea and has been described as a new species at least seven times. The Mindanao collections cited above fit well with the species description presented in Vitt et al. (1995). They differ mainly in having widely erect-spreading (not squarrose-recurved) leaves when wet, more narrowly acuminate leaf apices, and a calyptra with noticeably stiff and long hair.

Macromitrium yuleanum is best identified by its narrowly ovate-lanceolate to oblong lanceolate leaves with percurrent to short, excurrent costa, and a weakly differentiated border of 1 to 2 rows of short rectangular, smooth cells near the denticulate apex and along the margins of the upper half of leaf. The laminal cells vary from mammillose to unipapillose. The setae are long, reaching more than 15 mm. The perichaetial leaves have a very long excurrent costa, nearly of the same length of lamina in some leaves.

Among the local congeners, *M. longicaule* Müll. Hal. is most similar in plant habit and leaf characters to *Macromitrium yuleanum*, but the former has percurrent leaf costa and short seta less than 5 mm long. Likewise, the somewhat look-alike *M. macrosporum* Broth. differs from *M. yuleanum* in having the percurrent leaf costa that ends at an incurved and entire apex. The leaf cells are nearly smooth and only slightly mammillose, but not unipapillose like in some leaves of *Macromitrium yuleanum*. The calyptra of *M. macrosporum* is also smooth with no hairs. *Macromitrium yuleanum* can also be mistaken for *M. ochraceum*, which is more commonly encountered in Mindanao Island. According to Eddy (1996), it can be separated from the latter by its less acute and shorter leaf apices with setae twice as long as that of *M. ochraceum*.

Macromitrium yuleanum was previously viewed as an endemic species of New Guinea and Solomon Islands.

***Macromitrium blumei* Nees ex Schwägr. [syn. *M. zollingeri* Dozy & Molk.; *M. blumei* var. *zollingeri* (Mitt. ex Bosch & Sande Lac.) S. L. Guo, B. C. Tan & Virtanen]**

SPECIMENS EXAMINED:— **Mindanao Island**: Bukidnon Province, saddle below the summit of Mt. Dulang-Dulang in Mt. Kitanglad Range Natural Park, on branches, 24 Apr 2014, *Shevock & B.C. Tan 44874* (CAS, CMUH, UC); ibid, Mt. Kiamo, along ridge trail to summit, on fallen hardwood branch, 7 May 2014, *Shevock & B.C. Tan 45141* (CAS, CMUH, UC); ibid, Mt. Limbawon, trail along ridge top at 1885 m elev. from campsite about 9 km distance above Kibalabag village, on branch of *Dacrydium* in open site of montane forest, 30 Jun 2015, *Shevock et al. 47042* (CAS, CMUH, UC); Davao Oriental Province, along trail from Camp 2 near pygmy forest to summit of Mt. Hamiguitan, 1175–1350 m elev., on small diameter tree trunk in sun, 22 Jun 2015, *Shevock & Yorong 46903, 46912* (CAS, CMUH, UC).

This is a common species in the Philippines and also a widespread member of the genus in Malesia. On Mindanao Island, it has been reported only from Mt. Candoon in Bukidnon Province and Mt. Apo Natural Park. The collections cited above expand the distribution of this species in Mindanao.

Macromitrium blumei is interpreted by us as a polymorphic species that exhibits both smooth and strongly bulging upper leaf cells. The synonymy between *M. blumei* and *M. zollingeri* was suggested by Eddy (1996) and agreed by us after we examined many packets of Mindanao specimens of these two taxa. The coiling leaves around the short branches, when dry, give the shoot a characteristic rope-like appearance (Eddy 1996). The small plant size, coupled with a somewhat asymmetrically obtuse leaf apex and a short to moderately long, excurrent costa, are additional diagnostic characters of this species. *Macromitrium blumei* is a widespread and common species in Malesia.

***Macromitrium cuspidatum* Hampe**

SPECIMENS EXAMINED:— **Camiguin Island**: Municipality of Mambajao, Mt. Hibok-Hibok, along Tagdo Trail to the summit at 710 m elev., on tree trunk in filtered sunlight, 8 Jul 2015, *Shevock & B.C. Tan 47157* (CAS, CMUH, UC). **Mindanao Island**: Davao Oriental Province, along trail from Camp 2 near pygmy forest to summit of Mt. Hamiguitan, 1040 m elev., on tree trunk in filtered sunlight, 22 Jun 2015, *Shevock & Yorong 46898* (CAS, CMUH, UC); ibid, along trail from Camp 2 to Twin Falls, mid-slope of Mt. Hamiguitan, 900–960 m elev., on tree trunk in filtered sunlight, 23 Jun 2015, *Shevock & Yorong 46937, 46953* (CAS, CMUH, UC).

This is a distinctive species of *Macromitrium* in the Philippine moss flora and can be easily identified by the nearly all oblong to elongate and smooth leaf cells, coupled with a long excurrent costa. The plants are yellowish green in color and moderately large in size, which make the sporophyte look small in comparison. It has been reported from many places in island groups of Luzon, Mindoro, Palawan and Visayan Region (Tan and Iwatsuki 1991), but not from Mindanao Island until a report on the mosses of Mt. Kiamo in Bukidnon Province, was published by Tan et al. (2015). The above cited collections provide a north and south distribution range extension across Mindanao Island. *Macromitrium cuspidatum* is a widespread species in Malesia but not as commonly encountered as *M. blumei*.

***Macromitrium microstomum* (Hook. & Grev.) Schwägr. [syn. *M. reinwardtii* Schwägr.]**

SPECIMEN EXAMINED:— **Mindanao Island**: North Cotabato Province, Mt. Apo, toward Lake

Ma-ag above the Geothermal Production Field of EDC, 1 May 2014, *Shevock 45012* (CAS, CMUH, UC).

According to Eddy (1996) and Vitt et al. (1995), this species is characterized by having smooth and flat lamina cells throughout the leaf, ovoid capsules borne on a long seta reaching often to 1.5 cm, and a naked, plicate calyptra.

Macromitrium microstomum, had been known earlier from the Philippines by its synonym, *M. reinwardtii*, and had already been reported from Luzon, Mindoro, and some islands in the Visayan Region (Tan and Iwatsuki, 1991); we now add Mindanao to the list. Otherwise, *Macromitrium microstomum* is widespread throughout tropical SE Asia reaching Australia, New Zealand, and Oceania. It is known also from Mexico, Guatemala, Costa Rica and the Caribbean Islands (Vitt et al. 1995).

***Macromitrium ochraceum* (Dozy & Molk.) Müll. Hal.**

Specimens examined:— **Mindanao Island**: Bukidnon Province, Mt. Kiamo, along ridge trail to summit in mixed hardwood-podocarp shrubland, on small tree trunk, 7 May 2014, *Shevock & B.C. Tan 45171* (CAS, CMUH, UC); ibid, Mt. Limbawon, trail along ridge top at 1800–1885 m elev. from campsite about 8–9 km distance above Kibalabag village, on ground and branch of *Dacrydium* in open site of montane forest along a cascading stream, 30 Jun 2015, *Shevock et al. 47037, 47041* (CAS, CMUH, UC); Davao Oriental Province, Mt. Hamiguitan, volcanic rock wall, 22 Jun 2015, *Shevock & Yorong 46919* (CAS, CMUH, UC), hardwood branch, 24 Jun 2015, *Shevock 46972* (CAS, CMUH).

Although this species is not new to Mindanao Island, it was previously known from only a single locality. These collections represent a distribution range extension of this large-sized *Macromitrium*. Bartram (1939) commented that "the long, ruddy, sparingly branched secondary stems and the very rough setae quickly establish the identity of *M. ochraceum*". According to Vitt et al. (1995), its smooth to slightly bulging, upper laminal cells and the narrowly elongate, straight, thick-walled and tuberculate basal leaf cells add to its species distinctiveness. A good illustration of this species appears in Eddy (1996).

On Mindanao, *M. ochraceum* is rather variable in its plant size, and, thus, also the coarseness of its stems. In herbarium collections, specimens of *M. ochraceum* are likely to be misidentified as *M. longicaule* Müll. Hal., which has a similarly large plant size, long branches, and curvy, dry leaf foliation. The former species however, has short and papillose setae less than 1 cm long, whereas the latter has smooth setae more than 1 cm long. The leaf cells of *M. ochraceum* are smooth to mamillose and bulging, not pluripapillose like the leaf cells of *M. longicaule*. *Macromitrium ochraceum* is a widespread species at higher elevations in Malesia.

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imaging system, Project Lab, California Academy of Sciences with credit given to the photographer Kathryn Whitney. Also, we again want to take note, with thankful appreciation, for the loan of Dr. Eddy's material labeled '*Macromitrium* sp.' by the British Museum (BM). Lastly, we gratefully acknowledge the thoughtful comments provided by Dr. Thomas Daniel who perused an early version of the manuscript and to two anonymous reviewers.

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Appendix I

List of 19 *Macromitrium* species and one variety reported for the Mindanao Region. An asterisk (*) indicates a new distribution record for a species reported in this publication, while two asterisks (**) indicate a species new to science.

Macromitrium angustifolium Dozy & Molk.— Camiguin Island: Mt. Timpoong, Mt. Hibok-Hibok (Linis, 2010).

Macromitrium archboldii E.B. Bartram — Mindanao Island: Mt. Kitanglad Natural Park (Tan et al. 2000).

Macromitrium blumei Nees *ex* Schwägr.— Mindanao Island: Mt. Candoon, Mt. Apo, Mt. Kitanglad Natural Park, Mt. Kiamo, Mt. Limbawon, Mt. Hamiguitan (Bartram, 1939; Tan and Iwatsuki, 1991; this publication).

Macromitrium cuspidatum Hampe — Mindanao Island: Mt. Kiamo, Mt. Hamiguitan (Tan et al. 2015); (this publication).

***Macromitrium eddyi* B.C. Tan & Shevock, sp. nov.— Mindanao Island: Mt. Kitanglad Natural Park (this publication).

Macromitrium falcatulum Müll. Hal.— Mindanao Island: Banga in Zamboanga Province (Bartram, 1939; Tan and Iwatsuki, 1991).

Macromitrium foxworthyi Broth.— Mindanao Island: Sax River in Zamboanga Province (Tan and Iwatsuki, 1991).

Macromitrium fuscescens Schwägr. [syn. *M. semipellucidum* Dozy & Molk.] — Mindanao Island: Camp Keithley in Lake Lanao Province, Agusan Province (Bartram, 1939; Tan and Iwatsuki, 1991).

Macromitrium incurvifolium (Hook. & Grev.) Schwägr. [syn. *M. subtile* Schwägr., *M. subuligerum* Bosch & Sande Lac.] — Camiguin Island: Mt. Timpoong, Mt. Hibok-Hibok. Mindanao Island: Alag River (Tan and Iwatsuki, 1991; Linis, 2010).

Macromitrium longicaule Müll. Hal.— Mindanao Island: Mt. Apo, Mt. Kitanglad (Tan and Iwatsuki, 1991).

Macromitrium macrosporum Broth. [syn. *Macromitrium goniostomum* Broth.] — Mindanao Island: Mt. Apo (Bartram, 1939; Tan and Iwatsuki, 1991).

**Macromitrium microstomum* (Hook. & Grev.) Schwägr. [syn. *M. reinwardtii* Schwägr.] — Mindanao Island: Mt. Apo (this publication).

Macromitrium mindorense Broth.— Mindanao Island: Davao Province (Tan and Iwatsuki, 1991).

Macromitrium ochraceum (Dozy & Molk.) Müll. Hal.— Mindanao Island: Mt. Malindang, Mt. Kiamo, Mt. Limbawon (Bartram, 1939; Tan and Iwatsuki, 1991; this publication).

Macromitrium orthostichum Nees ex Schwägr.— Camiguin Island: Mt. Timpoong, Mt. Hibok-Hibok. Mindanao Island: Sax River in Zamboanga Province (Bartram, 1939; Tan and Iwatsuki, 1991; Linis, 2010).

Macromitrium salakanum Müll. Hal.— Camiguin Island: Mt. Timpoong, Mt. Hibok-Hibok (Bartram, 1939; Tan and Iwatsuki, 1991; Linis, 2010).

Macromitrium salakanum Müll. Hal. ssp. *celebense* (Paris) M. Fleisch.— Mindanao Island: Mt. Apo, Sax River in Zamboanga Province, Agusan Province (Bartram, 1939; Tan and Iwatsuki, 1991).

Macromitrium sulcatum (Hooker) Bridel — Mindanao Island: Mt. Candoon (Bartram, 1939; Tan and Iwatsuki, 1991).

**Macromitrium tylostomum* Mitt. ex Bosch & Sande Lac.— Mindanao Island: Mt. Apo (this publication).

**Macromitrium yuleanum* Broth. & Geh.— Mindanao Island: Mt. Kitanglad Range Natural Park (this publication).